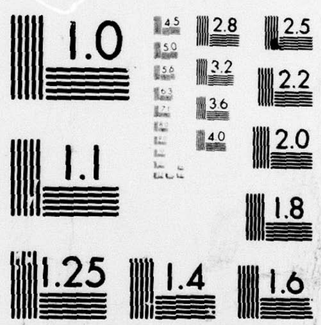
AD-A078 980 TEXAS A AND M UNIV COLLEGE STATION DEPT OF METEOROLOGY F/G 4/2
THE DETERMINATION OF ATMOSPHERIC STRUCTURE FROM QUANTITATIVE SA--ETC(U)
DEC 79 J R SCOGGINS DAAG29-76-G-0078

UNCLASSIFIED ARO-13520.7-ASX NL

1 OF 1
AD
A078980

END
DATE
FILMED
2-80
DDC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

ARO 13520.7-GSX

12

THE DETERMINATION OF ATMOSPHERIC STRUCTURE FROM QUANTITATIVE SATELLITE DATA

LEVEL II

Final Report

James R. Scoggins

3 December 1979

U. S. Army Research Office
Durham, North Carolina

Grant No. DAAG 29-76-G-0078

Texas A&M University
College Station, Texas 77843

Approved for Public Release; Distribution Unlimited.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 The Determination of Atmospheric Structure from Quantitative Satellite Data		5. TYPE OF REPORT & PERIOD COVERED Final. Jan. 1976-Aug. 1979
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 James R. Scoggins		8. CONTRACT OR GRANT NUMBER(s) 15 DAAG 29-76-G-0078
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Meteorology Texas A&M University College Station, Texas 77843		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 12 8
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office P. O. Box 12211 Research Triangle Park, NC 27709 11		12. REPORT DATE 3 Dec[redacted]979
		13. NUMBER OF PAGES 5
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 18 ARO 19 13520.7-AS		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

9 Final rept. Jan 76 - Aug 79,

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Satellite data
Satellite vs rawinsonde data
Satellite vs rawinsonde comparisons
Synoptic analysis
Errors in satellite data

79 12 17 074

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The question regarding the extent to which satellite sounding data can be used to determine atmospheric structure was addressed. Comparisons were made between rawinsonde and satellite profiles in seven areas for a wide range of surface and weather conditions. Variables considered consist of temperature, dewpoint temperature, thickness, precipitable water, lapse rate of temperature, stability, geopotential height, mixing ratio, wind direction, wind speed, and kinematic parameters including vorticity and the advection of over

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified 400 161
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20. Abstract (Continued)

vorticity and temperature. In addition, comparisons are made in the form of cross sections and synoptic fields for selected variables.

Sounding data from both the NIMBUS-6 and TIROS-N satellites were used. The NIMBUS-6 data were linearly interpolated in order to obtain soundings coincident in time with the rawinsonde soundings. The TIROS-N data were obtained concurrently with the rawinsonde data and no interpolation was performed. Results from the analysis of the discrepancies between satellite and rawinsonde data were similar for both types of satellite data. Biases were observed in both sets of satellite data as a function of altitude, and the discrepancies were approximately randomly distributed in the 1000-500, 500-300, and 300-100 mb layers.

Geostrophic wind computed from smoothed geopotential heights provided large-scale flow patterns that agreed well with the rawinsonde wind fields. Surface wind patterns as well as magnitudes computed by use of the log law to extrapolate wind to a height of 10 m agreed well with observations.

The results of this study demonstrate rather conclusively that satellite profile data can be used to determine characteristics of large-scale systems, but that small-scale features such as frontal zones cannot yet be resolved satisfactorily.

PUBLICATIONS

1. Moyer, Vance, J. R. Scoggins, N. M. Chou, and G. S. Wilson, 1978: Atmospheric Structure Deduced from Routine Nimbus 6 Satellite Data. Mon. Wea. Rev., 106, 1340-1352.

2. Scoggins, J. R. and N. M. Chou, 1978: Discrepancies Between Rawinsonde and Satellite Profile Data as a Function of Altitude for Several Geographic Regions. Preprints Conference on Atmospheric Environment of Aerospace Systems and Applied Meteorology, New York, Amer. Meteor. Soc., 134-139.

3. Scoggins, J. R., W. E. Carle, Keith Knight, Vance Moyer, and N. M. Cheng, 1979: A Comparative Analysis of Rawinsonde and NIMBUS-6 and TIROS-N Satellite Profile Data. Summary Report, ARO Grant No. DAAG 29-76-G-0078, December, 70 pp.

4. Knight, Keith S., 1978: Atmospheric Structure Determined from Satellite Data. M.S. Thesis, Texas A&M University, August, 96 pp.

5. Chou, Nine-Min, 1979: Comparisons Between NIMBUS-6 Satellite and Rawinsonde Soundings for Several Geographical Areas. M.S. Thesis, Texas A&M University, May, 65 pp.

6. Carle, William E., 1979: Determination of Wind From NIMBUS-6 Satellite Sounding Data. M.S. Thesis, Texas A&M University, December, 73 pp.

SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED

James R. Scoggins, Professor and Principal Investigator
Vance E. Moyer, Professor
Aylmer H. Thompson, Professor
Gregory S. Wilson, Research Assistant
Keith S. Knight, Graduate Student (M.S. Degree Awarded August 1978)
Nine-Min Chou Cheng, Graduate Student (M.S. Degree Awarded May 1979)
William E. Carle, Graduate Student (M.S. Degree Awarded December 1979)
Karen Cobbs, Student Worker
Karen Hood, Student Worker

STATEMENT OF PROBLEM STUDIED

Quantitative satellite data in the form of soundings have recently become available in sufficient quantity for analysis of synoptic systems. Before these data can be used effectively in synoptic analysis and forecasting or for other purposes, a study was needed to determine the extent that atmospheric structure could be determined from the satellite profile data. This problem was approached in this study by examining discrepancies between rawinsonde and satellite profile data to determine some general features about possible errors in satellite data relative to rawinsonde data, and by comparing cross sections and constant pressure charts prepared from the two types of data.

SUMMARY OF IMPORTANT RESULTS

The results presented here were taken from the three theses and the summary report. These results include those presented in the other referenced material.

Mr. Knight's thesis:

1) Satellite-derived temperatures are not of desired accuracy for large-scale synoptic analysis although general patterns may be determined.

2) The satellite measurements of dew-point temperature are smoothed to such an extent that location of frontal zones and diagnosis of features on anything but a large scale is difficult.

3) The variables that seem to distinguish frontal structure and differences between air masses are the equivalent potential temperature, temperature, and lapse rate of temperature.

4) Differences in the accuracy with which geopotential height can be computed from satellite data do not affect the computations of geostrophic wind, so that differences in calculated winds are fairly consistent in the four regions considered.

Ms. Chou's thesis:

1) The approximate mean RMS of the discrepancies for profile pairs between satellite and weighted rawinsonde data for seven parameters are the following:

a) Temperature: 2 C
b) Dew-point temperature: 7.5 C
c) Layer thickness: 7 m km^{-1}
d) Mixing ratio: 1.34 g kg^{-1}
e) Precipitable water: 0.23 cm
f) Lapse rate of temperature: 1.1 C km^{-1}

g) All Showalter indexes derived from satellite data are positive, and the vertical totals index is within 5% of and smaller than those computed from rawinsonde data.

2) Good agreement between satellite and rawinsonde temperature data was found, although satellite moisture data are highly questionable.

3) The poorest agreement between satellite and rawinsonde temperature or temperature-derived parameters was found either near the tropopause region or near the ground. Average satellite temperature is higher in the tropopause region and lower near the ground than the rawinsonde temperature. The best agreement between the temperatures was found in the middle troposphere. The largest disagreement between satellite and rawinsonde dew-point temperatures was found in the layer between 500 and 300 mb.

4) Results for the four geographical areas studied show that the best agreement between satellite and rawinsonde temperatures and parameters derived from temperature is found over water (Caribbean) and the poorest agreement was found over the mountains (western United States).

5) In addition to instrument errors of the satellite sensors and rawinsonde observations, the discrepancies between satellite and rawinsonde data may be attributed to the following:

a) The distance between satellite and rawinsonde station pairs;

b) The smoothing of the satellite temperature profile due to the data processing method;

c) Moisture effects on the satellite sensors;

d) The type of underlying surface; and

e) Interpolation of the rawinsonde data.

Mr. Carle's thesis:

1) The best satellite-derived wind on constant-pressure charts is a geostrophic wind derived from highly smoothed fields of geopotential height. Use of the gradient wind approximation did not improve comparisons between satellite-derived and rawinsonde winds.

2) Circulation patterns from satellite-derived geostrophic and rawinsonde wind fields are similar in regions of moderate to large wind speeds, but may compare poorly in regions of small wind speeds.

3) Mean differences between satellite-derived geostrophic and rawinsonde wind speeds range from about -5 to 5 m s^{-1}. Magnitudes of the standard deviation of the differences in wind speed range from about 3 to 12 m s^{-1} on constant-pressure surfaces and peak at the jet-stream level.

4) Centers of maximum wind speed in satellite-derived wind fields may be displaced horizontally from the corresponding centers in rawinsonde data; a second maximum in wind speed may be present in satellite-derived winds where none exists in rawinsonde data. Satellite-derived and rawinsonde winds show good agreement on the altitude of the jet stream core, but the jet core from satellite data has smaller wind speeds and less vertical shear of wind than are present in the rawinsonde jet core.

5) Fields of satellite-derived surface wind computed with the logarithmic wind law agree well with fields of observed surface wind in most regions. Satellite-derived surface winds are able to depict flow across a cold front and around a low-pressure center. Magnitudes of the standard deviation of the differences in surface wind speed range from about 2 to 4 m s^{-1}, while magnitudes of the standard deviation of the differences in wind direction range from about 28 to 66°.

6) Rawinsonde and satellite-derived fields of temperature advection are similar at 850 and 500 mb. However, there is little correspondence between rawinsonde and satellite-derived fields of vorticity or vorticity advection at 500 mb.

Summary Report (Some of these conclusions overlap those presented above):

1) The approximate mean RMS of the discrepancies for profile pairs between Nimbus-6 and time-interpolated rawinsonde data for seven parameters and all seven areas are the following:

a) Temperature: 2 C
b) Dew-point temperature: 7.5 C
c) Layer thickness: 7 m km^{-1}
d) Mixing ratio: 1.34 g kg^{-1}
e) Precipitable water: 0.23 cm
f) Lapse rate of temperature: 1.1 C km^{-1}
g) All Showalter indexes derived from satellite data are positive, and the vertical totals index is within 5% of and smaller than those computed from rawinsonde data.

2) Cumulative frequency distributions show that discrepancies between Nimbus-6 and rawinsonde data can be represented by a normal distribution.

3) For temperature and temperature-related variables, there is a strong correspondence between gridded fields of rawinsonde and Nimbus-6 data. Temperature differences are significant only in regions of strong vertical or horizontal gradients. In cross sections and constant-pressure charts, the satellite data yield similar patterns to rawinsonde data, except that frontal contrasts are somewhat smoothed so that gradients behind fronts are not quite as strong in the satellite data. Differences between satellite and rawinsonde temperatures tend to be largest near the

tropopause and the ground. Lapse rate of temperature, along with temperature, is useful for determining frontal locations from satellite data.

4) For gridded fields of dew-point temperature and other measurements of moisture, the Nimbus-6 soundings present a smoothed version of rawinsonde soundings. Examination of dew-point temperature itself seems to yield poor results in terms of the depiction of frontal contrasts and in terms of quantitative differences between satellite and rawinsonde values. Equivalent potential temperature, which combines temperature and moisture measurements, is shown to be a better variable for depicting frontal locations.

5) Differences between rawinsonde and satellite-derived fields of geopotential height tend to increase toward the tropopause and decrease slightly above that level.

6) Results indicate that the best satellite-derived wind on constant-pressure charts is a geostrophic wind derived from highly smoothed fields of geopotential height. Satellite-derived winds computed in this manner and rawinsonde winds show similar circulation patterns except in areas of small height gradients. Magnitudes of the standard deviation of the differences between satellite-derived and rawinsonde wind speeds range from about 3 to 12 m s^{-1} on constant-pressure charts and peak at the jet-stream level.

7) Fields of satellite-derived surface wind computed with the logarithmic wind law agree well with fields of observed surface wind in most regions. Magnitudes of the standard deviation of the differences in surface wind speed range from about 2 to 4 m s^{-1}, and satellite-derived surface winds are able to depict flow across a cold front and around a low-pressure center.

8) Results obtained from the comparison of simultaneous TIROS-N and rawinsonde data are similar to those found for Nimbus-6 and time-interpolated data. The only significant change in the results was that found for the differences between satellite-derived and rawinsonde wind direction. Magnitudes of the average and standard deviation of the differences between TIROS-N and rawinsonde wind directions are approximately half as large as the corresponding differences for Nimbus-6 and rawinsonde data. The improved results for wind direction with TIROS-N data may be due to the synoptic conditions in the area or the use of simultaneous rawinsonde and satellite data.